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10/762,186	01/20/2004	Keng-Chu Lin	67,200-1142	4771

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EXAMINER	
DOTY, HEATHER ANNE	
ART UNIT	**PAPER NUMBER**
2813	

DATE MAILED: 09/29/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/762,186	LIN ET AL.	
	Examiner	Art Unit	
	Heather A. Doty	2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *20 January 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-22* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-3,5,7-16 and 18-22* is/are rejected.

7)☒ Claim(s) *4,6 and 17* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *20 January 2004* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Claim Objections

Claim 1 is objected to because of the following informalities: In line 11, the word "plasma" should be inserted between "with" and "comprising". Appropriate correction is required.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless – (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 1, 8, 9, and 12 are rejected under 35 U.S.C. 102(e) as being anticipated by Noguchi et al. (U.S. 2004/0152256).

Regarding claim 1, Noguchi et al. teaches a method for plasma-treating an exposed copper surface and dielectric insulating layer in a semiconductor device manufacturing process, comprising the steps of providing a semiconductor wafer giving an exposed copper portion (**19** in Fig. 4) and an exposed dielectric insulating layer portion (**16** in Fig. 4); plasma treating the process surface in a first plasma treatment with plasma comprising reduction gas (H_2—paragraph 0075) and nitriding gas (N_2—paragraph 0075); and plasma treating the process surface in a second plasma treatment with plasma comprising oxidizing gas (plasma CVD is used to deposit an oxygen-containing barrier layer—paragraph 0076).

Regarding claims 8 and 9, Noguchi et al. teaches the method of claim 1, and further teaches that the dielectric insulating layer comprises porous low-k material with a dielectric constant of between about 2.2 and about 3.0 (paragraphs 0065-0069).

Regarding claim 12, Noguchi et al. teaches the method of claim 1, and further teaches that the second plasma treatment is carried out in situ with respect to the first plasma treatment (paragraphs 0075-0076).

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless – (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claim 1 is rejected under 35 U.S.C. 102(b) as being anticipated by Ngo et al. (U.S. 2002/0162736).

Regarding claim 1, Ngo et al. teaches a method for plasma-treating an exposed copper surface and dielectric insulating layer in a semiconductor device manufacturing process comprising the steps of providing a semiconductor wafer comprising a process surface having an exposed copper portion (**20** in Fig. 2) and an exposed dielectric insulating layer portion (**23** in Fig. 2); plasma-treating the process surface in a first plasma treatment with plasma comprising reduction gas (NH_3) and nitriding gas (N_2—paragraph 0027); and plasma-treating the process surface in a second plasma treatment process with plasma comprising oxidizing gas (oxygen plasma used to remove photoresist—paragraph 0024; note that the claim as written provides no limitation requiring the first plasma process to occur before the second).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Noguchi et al. (U.S. 2004/0152256) in view of Bao et al. (U.S. 6,248,665).

Regarding claim 2, Noguchi et al. teaches the method of claim 1 (note 35 U.S.C. 102(e) rejection above), but does not teach pre-heating the process surface to a temperature of between about 200 °C and 350 °C prior to the first plasma treatment process.

Bao et al. teaches pre-heating a copper damascene structure at a temperature between 300 °C and 450 °C before plasma-treating the structure to relax the surface of the copper to improve adhesion to the copper in future processing steps (column 4, lines 39-48, column 5, lines 26-30).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to combine the teachings of Noguchi et al. and Bao et al. by using the method taught by Noguchi et al. and also taught by claim 1, and further pre-heat the process surface as taught by Bao et al. before performing a plasma treatment. The motivation for doing so at the time of the invention would have been to relax the

surface of the copper to improve adhesion to the copper in future processing steps, as expressly taught by Bao et al.

Claim 3 is rejected under 35 U.S.C. 103(a) as being unpatentable over Noguchi et al. (U.S. 2004/0152256) in view of Inukai et al. (U.S. 2005/0136644).

Regarding claim 3, Noguchi et al. teaches the method of claim 1 (note 35 U.S.C. 102(e) rejection above), but does not teach that the reduction gas comprises NH_3 and H_2.

Inukai et al. teaches a method of plasma treating a semiconductor wafer having an exposed copper surface and dielectric insulating layer using a reduction gas comprising NH_3 and H_2 to prevent formation of copper oxide on the exposed copper surface (paragraphs 0047, 0050-0051).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to combine the teachings of Noguchi et al. and Inukai et al. by using the method taught by Noguchi et al. and also taught by claim 1, and further use the reduction gas comprising NH_3 and H_2 taught by Inukai et al. The motivation for doing so at the time of the invention would have been to prevent formation of copper oxide on the exposed copper surface, and thereby enable excellent wiring formation, as expressly taught by Inukai et al. (paragraph 0051).

Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Noguchi et al. (U.S. 2004/0152256).

Regarding claim 5, Noguchi et al. teaches the method of claim 1 (note 35 U.S.C. 102(e) rejection above), but is silent regarding the ratio of reduction gas to nitriding gas

in the plasma gas source. However, it has been held that "where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation." *In re Aller* 105 USPQ233, 255 (CCPA 1955). Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to use the method taught by Noguchi et al. and by claim 1, and optimize the ratio of reduction gas to nitriding gas in the plasma gas source to result in a ratio between about 1 to 5 and about 1 to 60.

Claim 7 is rejected under 5 U.S.C. 103(a) as being unpatentable over Ngo et al. (U.S. 2002/0162736) in view of Hsieh et al. (U.S. 2003/0164354).

Regarding claim 7, Ngo et al. teaches the method of claim 1 (note 35 U.S.C. 102(b) rejection above), but does not teach that the second plasma treatment comprises a plasma gas source consisting essentially of O_2.

Hsieh et al. teaches a method of removing photoresist from a porous, low-k dielectric using a plasma consisting essentially of O_2 (paragraph 0092, Table 1).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to use the plasma etch chemistry taught by Hsieh et al. in the second plasma taught by Ngo et al., and also taught by claim 1, because it is known in the art to effectively remove photoresist from porous, low-k dielectrics, as shown by Hsieh et al. (paragraph 0092, Table 1).

Claims 10, 11, and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Noguchi et al. (U.S. 2004/0152256) in view of Buchwalter et al. (U.S. 6,261,951).

Regarding claim 10, Noguchi et al. teaches the method of claim 1 (note 35 U.S.C. 102(e) rejection above), but does not teach the step of blanket-depositing an etch-stop layer of an in-situ PECVD process with respect to at least the second plasma treatment.

Buchwalter et al. teaches plasma-treating a copper interconnect structure and then blanket-depositing an etch-stop layer (**24** in Fig. 1) of an in-situ PECVD process with respect to the plasma treatment to provide improved adhesion of the etch-stop layer to the copper wire with no increase in resistance (column 4, lines 31-50, column 6, lines 4-19).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to use the method taught by Noguchi et al. and also taught by claim 1 and further blanket-deposit an etch-stop layer of an in-situ PECVD process with respect to the plasma treatment, as taught by Buchwalter et al. The motivation for doing so at the time of the invention would have been to provide improved adhesion of the etch-stop layer to the copper wire with no increase in resistance, as expressly taught by Buchwalter et al.

Regarding claim 11, Buchwalter et al. teaches that the etch-stop layer is silicon nitride or silicon carbide (column 4, lines 31-50).

Regarding claim 13, Noguchi et al. teaches the method of claim 1 (note 35 U.S.C. 102(e) rejection above), but is silent regarding the pressures used to perform the plasma treatments.

Buchwalter et al. teaches plasma-treating copper interconnects at pressures between about 1 milliTorr and about 10 milliTorr (column 5, lines 19-21).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to use the method taught by Noguchi et al. and also taught by claim 1, and further perform the plasma treatments as pressures between about 1 milliTorr and about 10 milliTorr, as taught by Buchwalter, since these pressures are known in the art to adequately treat copper interconnects.

Claims 14, 16, and 19-21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ngo et al. (U.S. 2002/0162736) in view of Buchwalter et al. (U.S. 6,261,951), with Noguchi et al. (U.S. 2004/0152256) used to provide inherency for claim 19.

Regarding claims 14, 20, and 21, Ngo et al. teaches a method for plasma-treating a copper interconnect and low-k IMD layer in a semiconductor device manufacturing process comprising the steps of providing a semiconductor wafer comprising a copper interconnect formed in an IMD layer comprising porous low-k having a process surface comprising an exposed copper portion (**20** in Fig. 2) and an exposed IMD layer portion (**23** in Fig. 2); plasma-treating the process surface in a first plasma treatment process with plasma comprising ammonia (NH_3) and nitrogen (N_2) (paragraph 0027); and plasma-treating the process surface in a second plasma treatment process with plasma comprising oxygen (O_2) (paragraph 0024; note that the claim as written provides no limitation requiring the first plasma process to occur before the second).

Ngo et al. does not teach depositing an etch-stop layer over the process surface in a PECVD process (claim 14) or that the blanket-depositing is carried out in situ with respect to the second plasma treatment (further limited by claim 20) or that the etch-stop layer is selected from the group consisting of silicon nitride, silicon oxynitride, titanium nitride, silicon carbide, and silicon oxycarbide (further limited by claim 21).

Buchwalter et al. teaches plasma-treating a copper interconnect structure and then blanket-depositing an etch-stop layer consisting of silicon nitride or silicon carbide (**24** in Fig. 1) of an in-situ PECVD process with respect to the plasma treatment to provide improved adhesion of the etch-stop layer to the copper wire with no increase in resistance (column 4, lines 31-50, column 6, lines 4-19).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to use the method taught by Ngo et al. and also taught by claim 1 and further blanket-deposit an etch-stop layer of an in-situ PECVD process with respect to the plasma treatment, as taught by Buchwalter et al. The motivation for doing so at the time of the invention would have been to provide a copper barrier layer that also acts as an etch stop with improved adhesion to the copper wire with no increase in resistance, as expressly taught by Buchwalter et al.

Regarding claim 16, Ngo et al. and Buchwalter et al. together teach the method of claim 14, and Ngo et al. further teaches that the first plasma treatment comprises a plasma gas source comprising an ammonia to nitrogen ratio between about 1 to 5 and about 1 to 60 (paragraph 0027—130 sccm to 5,000 sccm is approximately a 1 to 40 ratio).

Regarding claim 19, Ngo et al. and Buchwalter et al. together teach the method of claim 14, and Ngo et al. further teaches that the IMD layer comprises a dielectric constant of between about 2.2 and 3.0 (paragraph 0024 teaches Black Diamond is an appropriate material for the IMD layer; Noguchi et al. (U.S. 2004/0152256) lists a dielectric constant of 2.4 – 3.0 for Black Diamond, see paragraph 0066).

Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ngo et al. (U.S. 2002/0162736) in view of Buchwalter et al. (U.S. 6,261,951) as applied to claim 14 above, and further in view of Bao et al. (U.S. 6,248,665).

Regarding claim 15, Ngo et al. and Buchwalter et al. together teach the method of claim 14 (note 35 U.S.C. 103(a) rejection above), but do not teach pre-heating the process surface to a temperature of between about 200 °C and 350 °C prior to the first plasma treatment process.

Bao et al. teaches pre-heating a copper damascene structure at a temperature between 300 °C and 450 °C before plasma-treating the structure to relax the surface of the copper to improve adhesion to the copper in future processing steps (column 4, lines 39-48, column 5, lines 26-30).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to combine the teachings of Ngo et al. and Buchwalter et al. and Bao et al. by using the method taught by Ngo et al. and Buchwalter et al. and also taught by claim 14, and further pre-heat the process surface as taught by Bao et al. before performing a plasma treatment. The motivation for doing so at the time of the

invention would have been to relax the surface of the copper to improve adhesion to the copper in future processing steps, as expressly taught by Bao et al.

Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ngo et al. (U.S. 2002/0162736) in view of Buchwalter et al. (U.S. 6,261,951) as applied to claim 14 above, and further in view of Hsieh et al. (U.S. 2003/0164354).

Regarding claim 18, Ngo et al. and Buchwalter et al. together teach the method of claim 14 (note 35 U.S.C. 103(a) rejection above), but do not teach that the second plasma treatment comprises a plasma gas source consisting essentially of O_2.

Hsieh et al. teaches a method of removing photoresist from a porous, low-k dielectric using a plasma consisting essentially of O_2 (paragraph 0092, Table 1).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to use the plasma etch chemistry taught by Hsieh et al. in the second plasma taught by Ngo et al. and Buchwalter et al. together, and also taught by claim 14, because it is known in the art to effectively remove photoresist from porous, low-k dielectrics, as shown by Hsieh et al. (paragraph 0092, Table 1).

Claim 22 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ngo et al. (U.S. 2002/0162736) in view of Buchwalter et al. (U.S. 6,261,951) as applied to claim 14 above, and further in view of Zistl et al. (U.S. 2003/0224599)

Regarding claim 22, Ngo et al. and Buchwalter et al. together teach the method of claim 14 (note 35 U.S.C. 103(a) rejection above), but do not teach that the second plasma treatment is carried out in situ with respect to the first plasma treatment.

Zistl et al. teaches performing plasma cleaning of a copper interconnect structure followed by plasma-treating the structure in situ with respect to the first plasma treatment (paragraphs 0026-0030). Performing the plasma treatments in situ with respect to each other protects the cleaned surface between plasma processes (paragraph 0012).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to use the method taught by Ngo et al. and Buchwalter et al. together, and also taught by claim 14, and further perform the plasma treatments in situ with respect to each other, as taught by Zistl et al., to protect the cleaned surface between plasma processes, as expressly taught by Zistl et al.

Allowable Subject Matter

Claims 4, 6, and 17 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter:

Regarding claim 4, prior art does not teach or suggest, in combination with the other claimed limitations, plasma-treating a process surface comprising an exposed copper portion and an exposed IMD portion using a nitriding gas comprising all of N_2, N_2O and NH_3.

Regarding claims 6 and 17, prior art does not teach or suggest, in combination with the other claimed limitations, plasma-treating a process surface comprising an

exposed copper portion and an exposed IMD portion using a plasma gas source comprising O_2 and additionally one of O_3, CO, CO_2, NO, or N_2O.

Conclusion.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Heather A. Doty, whose telephone number is 571-272-8429. The examiner can normally be reached on M-F, 8:30 - 5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead, Jr., can be reached at 571-272-1702.. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

had

DAVID BLUM
PRIMARY EXAMINER